Year 2000
Medical Testing of Individuals Potentially Exposed To Asbestoform Minerals Associated with Vermiculite in Libby, Montana

A Report to the Community

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Agency for Toxic Substances and Disease Registry
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Table 9. Crude Rates and Odds Ratios by Cigarette smoking History

		Pleural Findings - All Views				
Smoke	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
Never	2644	2328	316	12.0	1.0	0
Ex-Smoker	1784	1281	503	28.2	2.9	2.5 - 3.4
Current	1160	986	174	15.0	1.3	1.1 - 1.6

Table 10 shows proportions and odds ratios for pleural abnormalities by body mass index. Those with a high body mass index were more likely to have a finding of pleural abnormalities. The risk for pleural abnormalities increases with increasing quartiles of BMI.

Table 10. Crude Rates and Odds Ratios by Body Mass Index

		Pleural Findings - All Views				
BMI	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
1st Quartile	1170	1069	101	8.6	1.0	0
2nd Quartile	1252	1073	179	14.3	1.8	1.4 - 2.3
3rd Quartile	1485	1203	282	19.0	2.5	2.0 - 3.2
4th Quartile	1627	1208	419	25.8	3.7	2.9 - 4.6

Table 11 shows crude proportions and odds ratios for pleural abnormalities by length of residency in the Libby area. Those who lived in the Libby area for 35 years or longer were more likely to have pleural abnormalities than those who did not (33% vs. 12%).

Table 11. Crude Rates and Odds Ratios by Length of Residency

		Pleural Findings - All Views				
ResDur	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
0-14 Years	1221	1080	141	11.6	1.0	0
15-22 Years	1342	1209	133	9.9	0.8	0.7 - 1.1
23-34 Years	1501	1277	224	14.9	1.3	1.1 - 1.7
35+ Years	1501	1008	493	32.8	3.8	3.1 - 4.6

Multivariate Analysis - Adjusted Rates

The crude and univariate analyses considered thus far do not account for the possibility that individual associations can become weaker or stronger in the presence of other variables (known as interaction), nor do they account for the possibility that factors may confound each other. The multivariate analysis overcomes these limitations and is a useful tool for assessing the effect of several factors acting together and their association with an outcome.

Multivariate logistic regression was used to assess the association between pleural abnormalities and 18 exposure pathways, while adjusting for age, sex, BMI, cigarette smoking status, years lived in the Libby area, neighborhood environmental concern level, and pulmonary disease or pulmonary surgery or injury. The final model is displayed in Table 12.

Table 12. Results of Multivariate Logistic Regression Analysis

Variable	Level	Beta	P-Value	Odds Ratio
Intercept		-12.14	<0.01	
Workwr	Yes	2.05	<0.01	
Work2nd	Yes	0.32	0.02	1.38 (1.04-1.83)
HHWR	Yes	1.20	<0.01	
Vermpop	Sometimes	0.30	<0.01	1.35 (1.10-1.65)
	Frequently	0.26	0.14	1.29 (0.92-1.81)
Playball	Sometimes	-0.09	0.47	0.92 (0.73-1.16)
	Frequently	0.21	0.09	1.23 (0.97-1.56)
Vermplay	Sometimes	0.50	<0.01	1.65 (1.29-2.11)
	Frequently	0.57	<0.01	1.76 (1.31-2.36)
Subsex	Male	1.60	<0.01	
Resdur	15-22 Years	0.12	0.47	1.12 (0.82-1.55)
	23-34 Years	0.21	0.16	1.23 (0.92-1.64)
	35+ Years	0.72	<0.01	2.05 (1.56-2.69)
Age		0.43	<0.01	
BMI	2nd Quartile	0.32	0.06	1.37 (0.99-1.90)
	3rd Quartile	0.44	0.01	1.55 (1.13-2.12)
	4th Quartile	1.17	<0.01	3.21 (2.37-4.36)
Smoke	Ex-Smoker	0.35	<0.01	1.42 (1.16-1.74)
	Current	0.35	0.01	1.42 (1.10-1.85)
Age*Workwr	Yes	-0.02	0.04	
HHWR*Subsex	Yes*Male	-0.63	<0.01	
Age*ln(Age)		-0.07	0.01	

Final Model Fit: Hosmer-Lemeshow Goodness-of-Fit Test, Chi-Square = 4.33, DF = 8, Pr > Chi-Square = 0.83

The regression model can be used to make comparisons between various groups and to assess the relative importance of various exposure pathways and covariates in predicting pleural abnormalities.

The model shows that the following factors are associated with pleural abnormalities: having been a WRG worker or a secondary contractor at WRG; having been a household contact of a WRG worker; having frequently popped vermiculite, played in vermiculite piles or played at the

ballfields near the expansion plants; being male; being older; having lived in the Libby area for a longer period of time; having smoked cigarettes; and having a high BMI.

The model also shows that several of the variables interact with each other. For example, the odds of having a pleural abnormality among former WRG workers differs with age. As age increases, the odds of having a pleural abnormality increases, but not as quickly for former WRG workers as for non-WRG workers. The model also shows that odds of having a pleural abnormality among household contacts of former WRG workers is higher for females than for males.

The risk factors that produced the largest increase in the odds of finding pleural abnormalities were being a former WRG worker, being male, and being a female household contact of a former WRG worker. The model shows that the estimated odds of finding a pleural abnormality is 7.7 times greater for a former WRG worker when compared to a non-WRG worker of the same age, adjusting for all of the other variables in the model (i.e., assuming that the participants being compared are alike with respect to age, sex, BMI, residential history, cigarette smoking status, and other risk factors considered in the model). The model also shows that the estimated odds of finding a pleural abnormality is 4.97 times greater for males than for females after adjusting for other variables in the model. The estimated odds of finding a pleural abnormality is 3.3 times greater for females who were household contacts of former WRG workers when compared to females who were not. The corresponding increased odds for males is 2.7. The model also shows that as age increases the odds of finding a pleural abnormality increase, though the relationship is non-linear. For example, the estimated odds of finding a pleural abnormality for a 30 year old is 3.65 times greater than for a 20 year old. However, the odds reduce to 2.08 when comparing a 60 year old to a 50 year old. Among the non-occupational or household contact exposure pathways, playing in the vermiculite piles frequently was most associated with an increased odds of finding pleural abnormalities. Those who played in the piles frequently had an estimated odds of pleural abnormalities 1.76 times greater than those who never played in the piles. The model predicts that those participants with multiple exposures have increased risk of abnormal pleural findings than those with only a subset of the exposures. The majority of these participants reported multiple, rather than single exposure pathways.

The distribution of exposure pathways is displayed in Table 13. Only 2.6% of participants had no apparent exposure. Forty percent (40%) of the participants reported six or more exposure pathways.

Table 13. Distribution of Multiple Exposure Pathways for All Participants

Number of Pathways	Frequency	Percent	Percent With At Least This Number of Pathways
0	159	2.6	-
1	412	6.7	97.4
2	703	11.4	90.7
3	797	13.0	79.3
4	801	13.0	66.3
5	817	13.3	53.3
6	709	11.5	40.0
7	644	10.5	28.5
8	488	7.9	18.0
9	280	4.6	10.1
10	179	2.9	5.5
11	104	1.7	2.6
12	38	0.6	0.9
13	14	0.2	0.3
14	3	0.1	0.1
15	0	0.0	0.0
16	1	0.0	0.0

The prevalence rates for pleural and interstitial abnormalities among participants with multiple exposures compared wih those with no apparent exposures is displayed in Table 14.

Table 14. Dose Relationship - Background Rate

Exposure Classification	n	Pleural Findings - All Views		Interstitial Findings- PA View	
		Normal	Abnormal	Normal	Abnormal
No Apparent Exposure	122	116 (95%)	6 (5%)	121 (99%)	1 (1%)
1-3 Exposure Pathways	1569	1394 (89%)	175 (11%)	1559 (99%)	10 (1%)
4-5 Exposure Pathways	1488	1262 (85%)	226 (15%)	1471 (99%)	17 (1%)
6+ Exposure Pathways	2411	1824 (76%)	587 (24%)	2390 (99%)	21 (1%)

This table shows that 24% of persons reporting six or more exposure pathways (43% of participants with chest radiographs) had pleural abnormalities compared to only 5% in the no apparent exposure group. Of the interstitial findings in these groups, 1% occurred in the all exposure pathway groupings.

Pulmonary Function Testing

Pulmonary function testing identified 2.2% of men and 1.6% of women 18 years old and older with moderate-to-severe restriction in breathing capacity. Table 14 summarizes restrictive abnormalities identified in the pulmonary function tests by exposure pathway for those 18 years old and older. This does not include participants who had significant obstructive lung changes for whom restrictive changes could not be evaluated. Participants who reported they were former workers at WRG had the highest percentage of restrictive abnormalities of all exposure pathways. As with the interstitial changes seen on the chest radiographs, the number of participants with moderate-to-severe restrictive function was much lower than the number of participants with pleural abnormalities. There were no moderate-to-severe restrictive changes seen in participants less than 18 years old.

A multivariate logistic regression model showed that the following factors were associated with moderate-to-severe restrictive abnormalities: being a former WRG worker or having worked with vermiculite at a non-WRG job, having had chest surgery, being older, having a high BMI, and being a past or current smoker.

The risk factor that produced the largest increase in the odds of having a restrictive abnormality was being a current smoker. The estimated odds of a restrictive abnormality was 3.15 (1.4-7.0) times greater for a current smoker than that of a participant who never smoked. The estimated odds ratios for the other factors in the model were 3.0 (1.6-5.8) for those who reported having had chest surgery, 2.8 (1.2-6.7) for those in the highest BMI quartile, 2.4 (1.2-4.8) for former WRG workers, and 2.0 (1.1-3.6) for non-WRG workers exposed to vermiculite.

The model also shows that as age increases the odds of finding a restrictive abnormality increase. A 10-year increase in age results in an estimated increase of 10.8 for the odds of restrictive abnormality.

Participant-Reported Symptoms and Illnesses

Table 15 shows background rates of self-reported symptoms and illnesses. The most commonly reported illness was chest illness (28.1%). The most commonly reported symptom was shortness of breath (35.6%).